REAL TIME, MULTIPLE PATH VIDEO IMAGING SYSTEM

Background of the Invention

1. Field of the Invention

The invention relates to the field of real time video imaging systems using optical viewing devices, and in particular, to real time video imaging systems having multiple optical paths and associated video imaging systems, which can be used with conventional, unmodified optical viewing devices.

2. Description of Related Art

There is a continuing need for surveillance devices which allow a forward observer to provide live video imaging to a remote location. Conventional video cameras are available to create a video recording of a scene. Significantly, however, such cameras are often unsuitable for specialized situations such as military combat and news gathering activities. It is inconvenient and impractical to operate a conventional video camera under circumstances where the user may be engaged in intense combat or other activities which command the users concentration. Particularly in the case of military combat, it may be of great importance for a remote commander of troops or vehicles to be able to observe precisely the same scene which is being observed by an infantry soldier, artillery observer, anti-aircraft gunner, or submarine commander. Conventional video cameras often provide unsatisfactory performance in such circumstances because they fail to take advantage of the view enhancing devices to which an individual in the field may have access such as view magnifiers, night vision equipment, or wide field of power sights. It would be desirable to provide an imaging system which provides real time camera viewing through day or night viewing devices, which is easily adaptable for use with existing equipment. It would be further desirable to provide such an imaging system which allows forward observers to take advantage of such conventional day or night viewing devices in transmitting live video to a rear echelon.

Endoscopes having multiple optical paths and utilizing video cameras are disclosed in: US 4,963,906; US 4,839,723; US 4,594,608; and, US 4,439,030. Microscopes having multiple

optical paths and utilizing video cameras are disclosed in US 5,497,267; US 5,481,401; US 5,235,459, US 5,144,478; US 5,006,872; and, US 4,786,154.

A high resolution, super-micro CCD color camera is available from Toshiba Video Communication and Information Systems, Buffalo Grove, Illinois. Model IK-SM40A has a 1/4 ", 410,00-pixel CCD with microlens technology, requiring a minimum illumination of 15 lux at F1.6. The focus range is from 10 mm to infinity.

A number of wireless video communication devices are available from Premier Wireless, Inc., Livermore, California. Models CS-220 and CS-120 will process and transmit full color video and audio up in a range of several miles, and over any one of four user selectable channels. A number of multi-channel wireless communication devices for processing and transmitting full color video and audio are also available from TRON-Tek, Inc., Tulsa, Oklahoma, including models in the 1800 Series of video Equipment, operating in the 1710-1850 MHz range and the 2400 Series of video Equipment operating in the 2450-2483.5 MHz range. The 2400 Series includes, inter alia, models TT-245TAFS and TT-24RAFS. The 1800 Series includes, inter alia, models TT185TAFS and TT-18RAFS.

Stabilized hand-held binoculars are available from Fraser-Volpe Corporation, Warminster, Pennsylvania, as model STEDI-EYE® M-25.

None of the optical instruments in the patents listed above is part of a multiple source system wherein video information from human observers making simultaneous observations in various locations is simultaneously transmitted by a wireless communication carrier to a central location at which all of the real time video signals can be monitored simultaneously with the human observers.

Summary of the Invention

The problems of the prior art are solved by a real time, multiple path video imaging system in accordance with the inventive arrangements taught herein.

A real time, multiple path imaging system, in accordance with an inventive arrangement, comprises: a plurality of

independent optical viewing devices, each of the optical devices having at least one optical viewing path; an eyepiece terminating each of the optical viewing paths; a beam splitter removably attached to each of the optical viewing devices, each beam splitter having a first split beam path continuing the optical path and enabling optical viewing and a second split beam path; an electronic video imaging device removably attached to each of the viewing devices, in alignment with respective ones of the second split beam paths; a video processor coupled to each of the video imaging devices for creating a real time video signal representing images in the optical viewing path; and, a transmitter coupled to each of the video processors for wireless transmission of the respective video signal to a remote receiving station, the transmitted video signals being distinguishable from one another.

The respective beam splitters and the respective video imaging devices can be formed as part of an integral unit, the integral unit having means for removable attachment to the respective eyepiece.

In one embodiment, the video signals are distinguishable from one another at least by data in an on screen display added to the respective video signals by the respective video. In a second embodiment, the video signals are distinguishable from one another at least by respective transmission carrier frequencies. The data can identify the respective video processors and/or the data can information from a global positioning sensor.

At least one of the optical viewing devices can comprise a monocular, or a binocular, or a periscope or multiple mirrors.

The respective video processors and the transmitters can be formed as part of an integral unit, the integral units being connected to the respective imaging devices by respective flexible couplings.

In accordance with a presently preferred embodiment, the imaging system comprises a mounting structure for attaching the imaging system on a viewing portion of a viewing device.

A beam splitter is mounted on the mounting structure for transmitting in a first optical direction, an image observable through the viewing portion of the viewing device, and simultaneously transmitting the same image in a second optical direction to an electronic image sensing device. The electronic image sensing device is preferably a miniature video camera capable of converting the image into an electronic signal such as a standard video signal. The video signal may thereafter be communicated to a miniature transmitter for transmission of the signal to a remote location or the signal may be recorded.

The imaging device permits real time camera viewing through conventional viewing equipment such as binoculars, monoculars, periscopes, gunsights or other day/night viewing devices such as the 14X power M-25 day/night stabilized binoculars. An operator of the imaging system can use conventional viewing equipment in a normal manner and without internal modification of the basic optical or electronic system. The device is preferably designed to be interposed between an eyepiece of a conventional viewing device displaying an image to be viewed, and the observer's eye(s). The scene being viewed by the observer in the field can be transmitted to a remote receiver through a miniature camera.

A significant advantage of the system is that the mounting structure can be easily removed from conventional viewing equipment when not in use, and the basic viewing system will thereafter be restored to its original configuration.

Brief Description of the Drawings

There are shown in the drawings embodiments which are presently preferred, it being understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown.

Figure 1 is a block diagram of a camera control unit in accordance with an inventive arrangement.

Figure 2 is a pictorial illustration of a real time, multiple path video imaging system in accordance with an inventive arrangement.

Figure 3 is a pictorial illustration of a real time, multiple path video imaging system in accordance with another inventive arrangement.

Figure 4 is a diagrammatic view of one channel of a real time, multiple path video imaging system in accordance with the inventive arrangements shown in Figures 2.

Figure 5 is an exploded view illustrating attachment of a video camera to an eyepiece, in accordance with an inventive arrangement.

Figure 6 is a perspective view of Figure 5.

Figure 7 is a rear view of incorporating structure shown in Figure 6.

Figure 8 is a side view of an alternative embodiment of the real time, multiple path video imaging system in accordance with another inventive arrangement.

Figure 9 is a pictorial illustration of a real time, multiple path video imaging system in accordance with yet another inventive arrangement.

Detailed Description of the Preferred Embodiments

A real time, multiple path video imaging system in accordance with an inventive arrangement is shown in Figures 1 and 2 and generally designated in Figure 2 by reference numeral 100. The real time, multiple path video imaging system 100 shown in Figure 2 is embodied as the technological foundation for a military style surveillance team. Three of four military observers 101, 111 and 121 are shown in detail. A fourth observer is represented by phantom block 131. Each of the observers is provided with an optical viewing device, for example a pair of binoculars designated 102, 112 and 122.

Observer 101 has a tank 105 under surveillance along a line of sight 106. Observer 111 has a half-track truck 115 under surveillance along line of sight 116. Observer 121 has a helicopter 125 under surveillance, along a line of sight 126. As will be explained more fully in connection with Figures 1 and 4, each optical viewing device is provided with a video camera which supplies a video signal to a camera control unit by means of a video cable. Observer 101 has a camera control unit 103 which receives signals from video

cable 104. Observer 111 has a camera control unit 113 which receives video signals from cable 114. Observer 122 has a camera control unit 123 which receives video signals from cable 124.

Each camera control unit encodes the received video signal, and transmits the video signal through a wireless communication link to a central receiving station. Camera control unit 103 establishes a wireless communication link 107. Camera control unit 113 establishes a wireless communication link 117. Camera control unit 123 establishes a wireless communication link 127. The observer represented by block 131 establishes a communications link 137.

The video signals transmitted on the respective communication links are received by an antenna 25 of a receiver and decoder 26. Receiver and decoder 26 supplies a base band video signal, for example, to a video monitor 80. In this illustrated embodiment, the receiver and decoder 26 or the monitor 80 are provided with a channel selector for selectively observing the subject matter under surveillance by any one of the four observers.

A schematic diagram of an imaging system is shown in Figure 4. The imaging system is representative of such structure in each of the embodiments illustrated herein. A conventional viewing system, in this case a monocular body 10, is shown to illustrate the use of the invention. Monocular body 10 includes an eyepiece 12 and an eye lens 14 mounted therein. Monocular body 10 can be one half of a pair of binoculars, a periscope or other kind of optical viewing device.

An optical beam splitter 16 is interposed between the eye lens 14 and an observer's eye 18. When the monocular is in use, an image is transmitted through the eye lens 14, in the direction of the observer's eye 18. With the beam splitter 16 interposed between the eye lens 14 and the observer's eye 18, the transmitted image is partially diverted so that the image is directed in two directions. More particularly, the image is partially transmitted through the beam splitter 16, for observation by a user, and partially reflected by the beam

splitter so that it is incident on an electronic imaging device 20. The electronic imaging device converts the incident optical image from the beam splitter to an electronic image signal. In one embodiment, the electronic imaging device 20 is electronically connected to a transmitter 22 by means of a video cable 24. The transmitter 22 communicates with receiver 26 which is preferably at a remote location. A video monitor 80 is preferably provided at the remote location in order to permit viewing of the received electronic image signal.

In a more specific aspect, the beam splitter 16 is preferably an optical beam splitter. Such optical beam splitters can be provided in the form of prisms, which are well known in the optical field. Alternatively, any other suitable optical means may be used to perform the beam splitting function, provided that an image transmitted through the eye lens 14 is remains observable by the observer and a separate signal is transmitted to the imaging device 20.

The imaging device 20 may be comprised of any suitable electronic means for converting an incident optical image received from the beam splitter into an electronic image signal. One example of such a device would be a 1/4" super-micro color CCD camera with a 4mm, f2.5 lens, for example Model IK-SM40A from Toshiba Video Communication and Information Systems. The electronic image signal is preferably a conventional video signal, but the invention is not limited in this regard. The imaging device is preferably comprised of a CCD or charge coupled device and associated electronic processing circuitry to provide solid state imaging. Such imaging devices are well known to those of ordinary skill in the art. A focusing lens 21 may be provided between the CCD imager and the beam splitter, but is not required.

In a more specific aspect, the transmitter 22 converts an electronic image signal into an RF signal for transmission to a receiver. While an RF link is preferred in this regard, it should be noted that a cable link may also be used between the transmitter and receiver. In a preferred embodiment,

transmitter 22 may also contain a camera control unit. The camera control unit provides the scan, sync frequency, AGC and video processing for the CCD image sensor. The above descriptions relate to standard electronics provided with miniature camera and transmitter equipment.

A camera control unit is shown in block diagram form in Figure 1. The camera control unit is responsive to a composite video signal supplied by camera 20. The camera control unit comprises an encoder 22, a key pad 229 and a transmitter 240. The encoder 22 comprises a sync separator 220, a line selector 221, a line clock 222 and a dot clock 223. The dot clock 223 provides a clock signal for a read/write memory 225 and a read only memory character generator 226. The line clock 222 supplies a second clock signal to the read only memory character generator 226. Key pad 229 can be used to enter an identification code which distinguishes the source of the video signal ultimately transmitted to the central location from the other transmitted video signals. A key pad decoder 224 provides an input to the read/write memory 225, responsive to the key pad 229. The characters generated in response to the key pad 229 are stored in a shift register 227, and supplied to a video adder 228. The composite video signal is also an input to video adder 228, the output of which includes the source identifying information as an on-screen display. The video signal with the source identifying information is an input to transmitter 240, which establishes the wireless communication link with the central location.

Another embodiment of the invention is shown in Figure 3 and generally designated by reference numeral 300. In Figure 3, the real time, multiple path video imaging system is utilized by a tank squadron. An observer 301 in tank 302 transmits a video signal from antenna 303 on a wireless communication link 304. An observer 311 in tank 312 transmits a video signal from antenna 313 on a wireless communication link 314. An observer 321 in tank 322 transmits a video signal from antenna 323 on a wireless communication link 324. A fourth observer in a tank is represented by block 331 and

wireless communications link 334.

A receiver and encoder 26 has an antenna 25. In a first alternative, a video cable 27 supplies video signals to each of video monitors 81, 82, 83 and 84. Each of these monitors can be tuned to one of the respective channels corresponding to the wireless communication links, so that the situations under surveillance by each of the observers can be monitored simultaneously. In another alternative, a video cable 29 represented in phantom supplies a signal to a monitor 85 which can display each of the pictures simultaneously, in respective quadrants.

Yet another embodiment of the real time, multiple path video imaging system is illustrated in Figure 9. The imaging system in Figure 9 is generally designated by reference numeral 400, and includes a satellite link. Although only one observation position is illustrated in Figure 9, the system comprises multiple observer positions, as shown in each of Figures 2 and 3. In Figure 9, a pair of stabilized binoculars 402 enables surveillance of a tank 405 along a line of sight 406. The binoculars 402 can be stabilized hand-held binoculars available from Fraser-Volpe Corporation as Model STEDI-EYE® M-25. An attachment arrangement 408 for a video camera (not shown in detail), is mounted on one of the eyepieces of the binoculars 402. A video cable 404 supplies a video signal to an encoder and transmitter 403. Transmitter 403 establishes a wireless communication link with a satellite station 410, which itself establishes a further wireless communication link with a central headquarters location 416 through a satellite 412. A monitor 418 in the central headquarters 416 can display an image 405′ of the tank under surveillance by the binoculars 402. The video signal can be recorded by video recorder 420. It will be appreciated that the real time, multiple path imaging system in accordance with the inventive arrangement shown herein can provide real time video from surveillance teams almost anywhere in the world to a central headquarters almost anywhere else in the world.

A mounting arrangement for a beam splitter and video camera is illustrated in Figures 5 and 6. An eyepiece 28 of a

binocular, for example a STEDI-EYE® M-25 stabilized binocular, has an annular groove 29, which is typical of most eyepieces. In some cases, the body of the eyepiece is not grooved, but a projecting rim defines a part of an annular groove. A mounting ring 30 has a substantially L-shaped cross-section, defining an annular base portion and an annular wall portion. A portion 31 of the annular wall portion is cut away or notched to receive the barrel of camera 20. The beam splitter 16 and camera 20 are mounted in a circular member 35 which also has at least one annular groove. Member 35 is positioned inside of ring 30, against the base portion, with the camera 20 disposed in the cutaway portion 31. Member 35 is held in the ring 30 by a plurality of set screws 33. Ring 30 can be provided with different inside diameter openings, so as to accommodate attachment to different eyepieces. The inner diameter of the wall portion of ring 30 can be uniform, so that one size of member 35 will fit all adapters and all eyepieces. The ring 30, with attached member 35, is held in place by thumbscrews 32.

The camera 20 is mounted in a barrel 39 affixed to the ring 30, and held in place by a set screw 38. Barrel 39 has a radially outwardly directed threaded end. Strain relief for the cable 24 is provided by an end cap 36 and a slotted grommet 37. End cap 36 has a radially inwardly directed threaded end. An eyeshield 44, which is normally mounted in the groove on the eyepiece, is removed from the eyepiece, and can be reattached to a groove on member 35.

The installation process can be as follows. The set screw for the camera is very lightly tightened. Member 35, with camera 20 and beam splitter 16, is affixed to the proper size ring 30 with the set screws. The video camera system is then turned on, and a distant object or scene, preferably 1500 meters or more away, is used to focus the camera lens for the sharpest picture (an infinity focus). The eye cup or eye shield is then removed from the eyepiece, and the ring 30 is slipped over the eyepiece and lightly secured by the thumbscrews. The camera is then inserted into the camera tube and secured by a set screw. While observing the video image

on a video monitor, the camera is rotated until the picture is right side up and reasonably straight. The set screw is then further gently tightened, just enough to hold the camera in place. The thumbscrews are loosened just enough to allow the diopter ring to be turned, and the diopter ring is turned until the reticle image, as viewed on the video monitor, is in sharpest focus. The ring is rotated slightly, as necessary, to insure that the video image is plumb. When the image is in a satisfactory orientation, the thumbscrews are tightened. To complete the installation, the split grommet is slipped onto the cable protruding from the end of the camera unit, approximately one inch from the camera back. The relief end cap is slipped over the cable, engaging the grommet with the notch on the end of the cap. The end cap and grommet are slid along the cable, over the protruding end of the camera to engage the threads on the end of the camera tube and the end cap is screwed onto the camera tube until tight.

When the imaging device according to the invention is not in use, it may easily be removed from the associated viewing equipment. The invention is particularly advantageous for use in conjunction with conventional viewing devices such as binoculars, monoculars, spotting telescopes, panoramic telescopes, direct fire gunsights and periscopes. Likewise, the invention may also be used with corresponding night vision versions of such viewing devices.

Figure 8 illustrates the present invention in use in connection with another type of conventional viewing device, in this case a wide field of view, unity power sight 50. As shown in Figure 8, the beam splitter 16 is mounted on a window or viewing screen 51. Window 51 is maintained in position by means of a frame 52, which also supports an imaging device 53. Optical beam splitter 16 is preferably adhered to window 51 by means of a U.V. lens bond 54. As with the previously described embodiment, the beam splitter is interposed between the image to be observed and an observer's eye 18. When the sight 50 is in use, an image incident on window 51 will be partially transmitted toward the users eye 18 and partially reflected toward imaging device 53. Imaging device 53

includes an objective lens 55, a photo-detector such as a CCD and associated video processing circuitry.

As illustrated by Figure 8, the invention is suitable for use with any heads up display (HUD) type sight or other sights which use a large exit pupil for two eyed viewing. This would include MGI VADS sights, armored driving periscopes, and binocular commanders sights.

In each of the embodiments disclosed herein, the wireless communication links or paths can be implemented by the wireless communication devices from Premier Wireless, Inc., for example, Models CS-220 and CS-120, and devices from TRON-Tek, Inc., for example, the 1800 and 2400 Series.

The invention as disclosed herein has been shown in several specific embodiments. Significantly, however, the invention is not limited in this regard. The imaging system can be used in conjunction with any conventional viewing system to provide video information to a remote location without interrupting on-site surveillance by an observer or team of observers.